The long-term blazar variability monitoring

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Abstract. Blazar Optical Sky Survey (BOSS Project) is a dedicated observational survey with the aim of monitoring known blazars in optical wavelengths. The project was initiated in March 2013 at the University of Athens Observatory (UOA0), performing ground-based optical photometric observations in parallel with orbital (SWIFT/XRT, Fermi LAT) X-ray observatories. BOSS Project immediately met international attention, attracting the interest of several collaborators worldwide. It is currently running as an international collaboration of the National and Kapodistrian University of Athens, utilizing the robotic and remotely controlled telescope at the UOA0. Several targets of interest are monitored in the frame of BOSS Project, such as highly variable blazars and AGNs. The targets are continuously observed on a daily basis, with the aim to achieve dense temporal coverage in optical wavelengths. Furthermore, simultaneous observations in high and low energy bands are cross-correlated with BOSS database and crucial information are gathered, in order to understand the mechanisms that are taking place in these objects. In this work, some of the major achievements after the first 4 years of operation of the BOSS Project are given, while the advantage of small, robotic and remotely controlled telescopes is highlighted.

Introduction

Blazar Optical Sky Survey (BOSS Project) is an observational survey of active blazars in optical wavelengths. It was initiated at the University of Athens Observatory (UOA0) in March 2013 under the coordination of Dr. Konstantas Gazeas. In the frame of BOSS Project, ground-based optical photometric observations are performed, in parallel with orbital X-ray observatories and ground-based radio telescopes. The BOSS Project, in collaboration with various institutes worldwide, including University of Athens (Greece), Turku Observatory (Finland), Institute of Geophysics and Planetary Physics (MPE) (Germany), Jagiellonian University of Krakow (Poland), University of Turku (Finland), and Wurzburg University (Germany). An example of two of the mostly observed blazars, the prototype BL Lac and the super-massive binary black hole OJ 287, is given in the plots below, highlighting the advantage of small, robotic and remotely controlled telescopes.

The observational strategy

The primary science goal of BOSS Project is to monitor the optical flux of several 3C and X-ray luminous blazars, which will allow to test models of the jet structure, kinematics chemical composition, magnetic field, and emission and light variability mechanism. Observations are obtained almost in a daily basis, monitoring intra-day variability (IDV) of blazars, or resulting in a very dense annual coverage. BOSS Project utilizes the robotic and remotely controlled telescope at the UOA0, which is equipped with a CCD camera and photometric filters in all optical bands. In the frame of BOSS Project, each target can be monitored several times within an observation run, and a full cycle of the target can be followed within a single night. The high percentage of clear sky (over 75% of useful nights within a year) allows the continuous monitoring of all program targets. BOSS Project can contribute to the field of High Energy Astrophysics, where there is poor coverage on low energy bands (optical) and follow-up observations, there is a need for cross-correlation studies, where multi-wavelength studies are essential for modeling purposes, or where rapid flux variability is “missed” in non-frequent monitoring campaigns. The carefully designed observing scheme maximizes the telescope’s efficiency, resulting in a large database of optical measurements taken with a single instrument, while creating a homogenous, dense, and uniform database of a large number of blazars.

BOSS Project preliminary results on the photometric variability of BL Lac data, spreading from 2014 to 2017. The variability of BL Lac (V) is displayed with the respect to the standard star GSC 1206 0097 (K). BL Lac is a highly variable optical source, the prototype of the entire class of active AGNs, known as blazars.

The long-term database

The Blazar M4241 was the first target to be observed in BOSS Project. It was later extended in several other targets, which are continuously monitored in a daily basis, with the aim to achieve a similar highly dense coverage in optical wavelengths. In parallel, other wavelengths are cross-correlated with our database, either with archival data or after requested to be observed (i.e. through proposals for orbital observatories). Recently (December 2016), BOSS Project was extended further in a few more targets (see table above), which show energetic and flaring behavior. Entering the fifth year of operation, BOSS Project keeps producing precious results, while the advantage of small, robotic telescopes is highly acknowledged. Among them, the multi-wavelength monitoring of the highly active blazar M4241 (Gazeas et al. 2013) and the monitoring of the ultrarelativistic flaring event of OJ 287 in December 2015 (Valtonen et al. 2016, Bhatta et al. 2016 and Zola et al. 2016) gives a good and representative list of the advantages, brought through a dedicated observational program. A similar example is the discovery of the OJ 287 binary black hole system, which is a result of an extensive monitoring program of quasars, carried out both in radio (Metehalli Radio Observatory, Helsinki) and in the optical (Tuorla Observatory, Turku), which started in 1980. Therefore OJ 287 is a perfect example of the need for long term commitment in scientific research.